Designation: D 1740 – 01

An American National Standard

Standard Test Method for Luminometer Numbers of Aviation Turbine Fuels[1]

This standard is issued under the fixed designation D 1740; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This test method has been adopted for use by government agencies to replace Method 2108 of Federal Test Method Standard No. 791b.

1. Scope

1.1 This test method[2] covers the measurement of the flame radiation characteristics of aviation turbine fuels and other similar distillate fuels expressed in terms of luminometer numbers. There is good correlation between smoke point (Test Method D 1322) and luminometer number which is presented in Appendix X1.[2]

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 7.1, 7.2, 8.1, 8.2 and Annex A1.1.

NOTE 1—It is the intent of Subcommittee J to ballot to withdraw this test method when due for reapproval in 2006, because of very limited and declining use to determine compliance with aviation turbine fuel specifications.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1322 Test Method for Smoke Point of Aviation Turbine Fuels[3]

D 1655 Specification for Aviation Turbine Fuels[3]

D 2880 Specification for Gas Turbine Fuel Oils[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *luminometer number*—a measure of flame temperature at a fixed flame radiation in the green-yellow band of the visible spectrum.

3.1.1.1 *Discussion*—It can be correlated with combustion characteristics of fuels for use in current commercial aviation turbine engines.

4. Summary of Test Method

4.1 The luminometer number of a fuel is determined by burning the fuel in the ASTM-CRC Luminometer lamp and obtaining a curve of flame radiation, as measured by an optical filter and photo cell unit against the temperature rise across the burner measured by a thermocouple placed just above the flame. This temperature rise is compared with that obtained on a pair of reference fuels at a constant radiation level. To ensure that the constant rating level is the same in all units, it is defined as the smoke point of tetralin. Luminometer number is calculated from the difference in temperature rise between the test fuel and the temperature rise for tetralin divided by the difference in temperature rise for *iso*octane and tetralin.

5. Significance and Use

5.1 This test method provides an indication of the relative radiation emitted by the combustion products of gas turbine fuels from a diffusion flame. The radiation level, expressed as luminometer number, is related to the hydrocarbon type composition of such fuels. A high luminometer number indicates a fuel of low radiation characteristics.

5.2 The luminometer number (and the smoke point with which it can be correlated) is qualitatively related to the potential radiant heat transfer from the combustion products of the fuel. Because radiant heat transfer exerts a strong influence on the metal temperature of combustor liners and other hot section parts of gas turbines, the luminometer number provides a basis for correlation of fuel characteristics with the life of these components.

6. Apparatus

6.1 *ASTM-CRC Luminometer,*[4] shown schematically in Fig. 1, consisting of three main parts:

6.1.1 A small wick-type lamp in which the sample is burned,

6.1.2 An optical filter and photocell circuit which indicates the intensity of flame radiation in the range from 4800 to 7000 Å and

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.J0 on Aviation Fuels.

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[2] This test method was developed on the basis of cooperative work carried out by the Coordinating Research Council and published in CRC Report "Evaluation of CRC Luminometer" (CRC Project No. CA-16-58). June 1959.

[3] *Annual Book of ASTM Standards,* Vol 05.01.

[4] The ASTM-CRC Luminometer, made by ERDCO Engineering Corp., 721 Custer Ave., P. O. Box 1310, Evanston, IL 60204 has been used to develop the precision of Test Method D 1740.

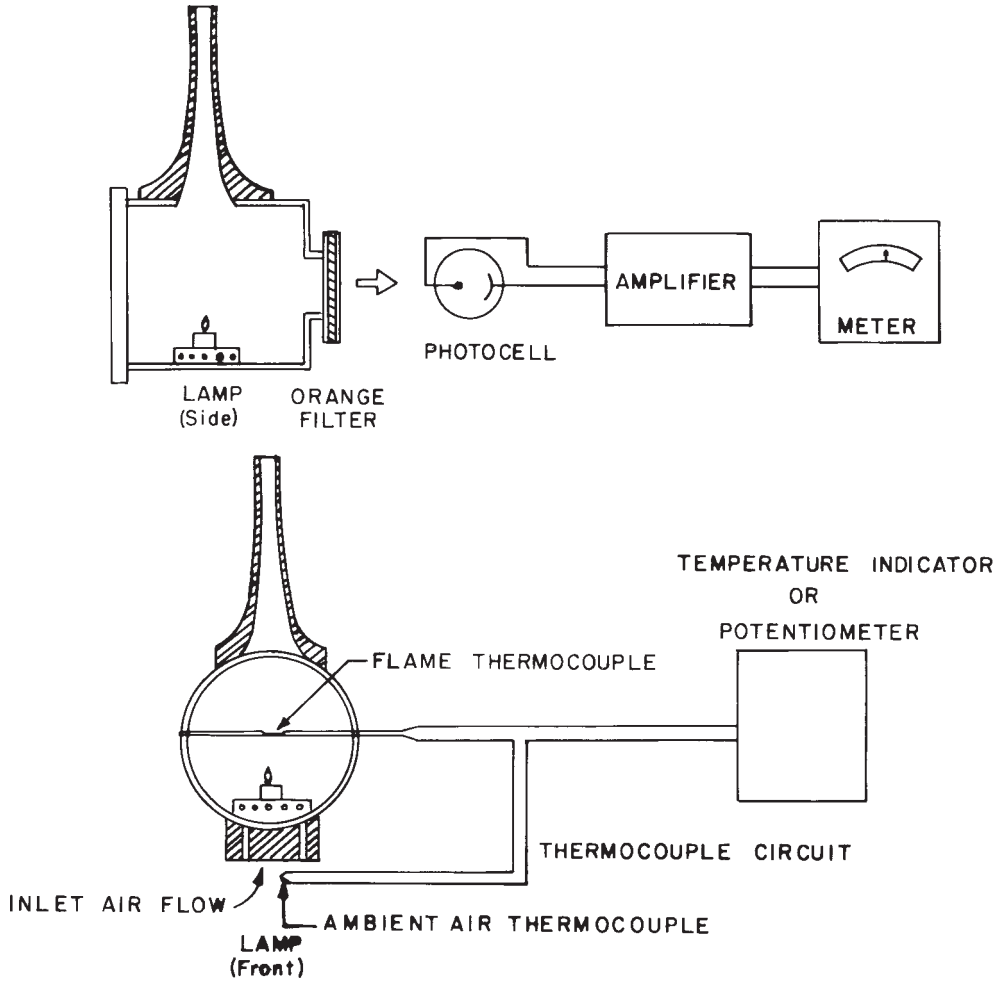


FIG. 1 Diagram of ASTM-CRC Luminometer

6.1.3 A system to measure the lamp temperature rise above ambient. Luminometers through serial No. 377 include a dual thermocouple circuit and potentiometer, while later instruments include a digital output unit.

6.2 *Lamp Wicks*—Standard ASTM smoke point lamp wicks[5] are used in the ASTM-CRC luminometer lamp.

7. Reference Materials and Reagent

7.1 *Isooctane* (**Warning**—Extremely flammable. Harmful if inhaled. Vapors may cause flash fire. See A1.1.) (*2,2,4-trimethyl pentane*) ASTM reference grade conforming to the following specifications:

Density at 20C, g/mL	0.69175 to 0.69205
Refractive index, $N_d^{20\,C}$	1.39135 to 1.39165
Freezing point, °C	−107.52
Distillation:	
Temperature at which 50 % is recovered, °C	99.20 to 99.30

7.2 *Tetralin*, (**Warning**—Combustible. Vapor harmful. In animal tests, repeated oral or inhalation exposures caused liver and kidney damage and the formation of eye cataracts. See A1.2.) conforming to the following specifications:

Specific gravity 25/25 C	0.969 to 0.97
Refractive index, $N_d^{20\,C}$	1.5396 to 1.5410
Distillation, from first drop to dry, °C	206 to 208

7.3 *Acetone, cp.* (**Warning**—Flammable. See A1.3.)

7.4 *Toluene, reagent grade*, (**Warning**—Flammable. See A1.4.)

7.5 *Methanol, reagent grade*, (**Warning**—Flammable. See A1.5.)

8. Preparation of Apparatus

8.1 *Cleaning the Lamp*—Before each test, clean the top and inside of the wick guide (in the lamp body) with acetone (**Warning**—Extremely flammable. Vapors may cause flash fire. See A1.3.) using a small test tube brush. Protect the optical filter with a tissue during cleaning. Check the filter for spots after cleaning and if the filter is found to be spotty, clean in place with lens tissue. If necessary, the filter can be removed for cleaning by first removing the lamp and then unscrewing the filter retaining ring. Following the replacement of the lamp, reference fuel checks should be made.

8.2 *Wicks and Sample Holders*—Only new wicks shall be used. Extract all wicks for at least 25 cycles in a reflux

[5] Standard smoke point wicks are obtainable through Erdco Engineering Corp., 721 Custer Ave., PO Box 1310, Evanston, IL 60204 and Koehler Instrument Co., 1579 Sycamore Ave., Bohemia, NY 11716.

condenser with an equal volume mixture of toluene (**Warning**—Flammable. Vapor harmful. See A1.4.) and anhydrous methanol (Note 2). (**Warning**—Flammable. Vapor harmful. May be fatal or cause blindness if swallowed or inhaled. Cannot be made nonpoisonous. See A1.5.) Allow the wicks to dry partially for 5 min, then place them in an oven and dry for ½ h at 100 to 110°C. Store in a dessicator until used. Thoroughly wash the sample holder in acetone and dry (Note 3). Then insert a dry wick in the wick tube of the clean sample holder. A piece of thin wire hooked through the end of the wick will allow the wick to be pulled through the tube without twisting. Use a clean razor blade or other sharp instrument to cut off the wick flush with the top of the wick tube (Note 4). Raise the wick by twisting the lower part until the end of the wick protrudes. Then, pull the wick up and remove any twists in the wick by rotating the ends of the wick. Also pull the wick down until the top of the wick is ¼ in. (6.4 mm) above the tube. Trim any frayed ends from the top of the wick. If the wick has not been cut square, recut and position as outlined above. (Note 5.)

NOTE 2—If extraction facilities are not available, request supplier to supply wicks that have been extracted.

NOTE 3—If either fuel or acetone vapors are not removed from the sample holder during the cleaning and drying operations, erroneous ratings can be obtained.

NOTE 4—Some razor blades have a protective chemical coating which should be removed with a solvent.

NOTE 5—An alternative method of preparing a wick free of twists and frayed ends utilizes a Wick Trimmer Assembly.[6] The wick trimmer holder is inserted over the top of the wick tube and the long-nosed triceps are inserted through the tube and holder. The wick is grasped and carefully pulled through the tube without twisting. A new clean sharp razor is used to cut the wick at the face of the holder and remove wisps and frayed ends. When the holder is removed, the wick will be at the correct height in the tube. The tube is then inserted into the candle and screwed home. The candle is inserted into the lamp.

8.3 The flame axis of the ASTM-CRC Luminometer lamp must be vertical for proper operation. Adjustable cabinet vibration mounts are provided for this purpose. Adjustment can be checked by a small level positioned on the large flame height adjusting ring. The level of the lamp should be checked in both the front to rear plane and the side to side plane. If at any time the position of the cabinet or the lamp is disturbed, the lamp level must be checked. If the position of the stack thermocouple is disturbed or the thermocouple replaced, the thermocouple should be positioned with the junction exactly on the lamp centerline. The bottom of the thermocouple shield should be exactly 1 in. (25.4 mm) above the wick guide. Suitable gages for this purpose are available from the manufacturer.

8.4 *Temperature Measurement*:

8.4.1 *Potentiometer* (Serial No. 377 and earlier)—Be sure the ambient air thermocouple is in its operating position (pulled to the right toward the lamp) and the stack thermocouple is connected. Turn the right switch of the potentiometer to TEST position; also turn the lower left switch to ZERO position and hold while adjusting the upper center knob until the galvanometer pointer rests at "0" (mechanical zero). Turn the lower left switch to STD and hold while adjusting the battery knob (upper left) until the galvanometer rests at" 0" (electrical zero). If the meter will not standardize, replace the internal potentiometer battery.[7]

8.4.2 *Temperature Indicator* (Serial No. 378 and higher)—Be sure the ambient air thermocouple is in its operating position (pulled to the right toward the lamp) and the stack thermocouple is connected. The output switch must be in the "OFF" position. Place the power switch in the "F"ahrenheit position. No additional adjustment is required. Return power switch to the "OFF" position between tests to conserve batteries. (Note 6.)

8.4.2.1 Four type 1.2 AHR SC Size rechargeable batteries are used to supply power for the unit. To recharge the battery pack, insert the battery charger plug into the "RECHARGE" jack located on the front panel. Use the 115 volt charger only on a 115 volt line (Note 6).

NOTE 6—For maximum battery life, it is recommended that the unit[7] be charged only when the discharged battery indication (display indicates HELP) is observed. Do not charge for periods longer than 18 h. Charge unit before initial use.

Display Symbols	
HI—	temperature over range
Help—	batteries discharged
F—	fahrenheit

8.4.3 *Digital Temperature Indicator (Serial No. 410 and Higher)*—Be sure the ambient air thermocouple is in its operating position (fully extended to the lamp) and the stack thermocouple is connected. Turn unit on by pressing the On/Off position on front key pad. Input temperature will be displayed.

8.4.3.1 Battery is a standard 9 V to supply power for the unit.

8.5 *Luminometer Meter*[8]—Turn the switch located below the right hand side of the luminometer meter to the OFF position. Adjust the meter to "0" by rotating the meter arm pivot screw on the lower front center of the meter. Then turn the switch to ZERO and turn the zeroing adjustment control located below the left-hand side of the meter until the meter arm rests at "0". To facilitate zeroing use the coarse and a fine zero adjustment. Next turn the switch to A_1, A_2, B_1, and B_2 to check the battery voltage. If on each switch position the meter rests above the appropriate mark on the meter scale, the batteries are satisfactory and the unit is ready for use. If the batteries are under strength, replace them. When replacing the "B" batteries also replace the photocell batteries located inside the photocell box.

9. Procedure

9.1 Introduce 20 mL of tetralin at room temperature into the clean dry sample holder. Place the wick tube into the top of the sample holder and screw tight. Run a small wooden applicator stick into the air vent hole in the bottom of the holder to free the vent of fuel. When the fuel rises to the top of the wick,

[6] Wick Trimmer Assembly, ERDCO Part No. 2LA-5520.

[7] Battery Pack, ERDCO Part No. 2LA-14229.

[8] ERDCO Part No. HCS-7962.

place the sample holder in the lamp and light it (**Warning**—Do not allow the flame to come closer than ⅛ in. (3.2 mm) from the thermocouple or the potentiometer (digital indicator-Serial Nos. 378 or higher) to read 1000°F (538°C) or higher). If any soot builds upon the thermocouple shield, put out the flame, clean the shield, lower the sample holder slightly and relight. Through the observation peep hole in the center of the lamp door note that the flame is burning free of smoke (Note 7). Let the tetralin burn at this level for 15 min to warm up the apparatus.

NOTE 7—All ASTM-CRC Luminometers have been adjusted by the manufacturer to read 45 to 55 at the smoke point of tetralin. If the unit is outside this range, adjust the internal resistor located between the two amplifier tubes (remove the rear cover of the unit) until a meter reading of 45 is obtained.

9.2 After warmup, lower the sample holder until the luminometer meter indicates approximately 30. Rezero the luminometer meter and potentiometer (6.1.3). Turn the luminometer meter switch to the TEST position. Wait at least 30 s for the indicator to stabilize after switching. Operate the luminometer at least 5 min at this position with the outer door closed in a draft-free environment. Record the luminometer meter and temperature indications (Note 8). Raise the wick and its holder until a luminometer reading approximately five units higher is indicated. Allow 5 min and again record the luminometer meter and temperature indications as above. Repeat this procedure until four data points are obtained; the last one being obtained at the flame height where a luminous tail (trace smoke) just breaks out of the tip of the flame. Soot would accumulate on the thermocouple at a slightly higher setting.

9.3 Plot the data points on a luminometer meter reading versus lamp temperature rise curve. All points should fall on a smooth curve. The top point (smoke point of tetralin) will represent rating level (meter reading) for all samples to be tested in this instrument. Repeat four times to establish the average rating level for the instrument (see Fig. 2).

NOTE 8—The rebalancing can be facilitated by putting a 40 to 60-mesh screen in front of the opening.

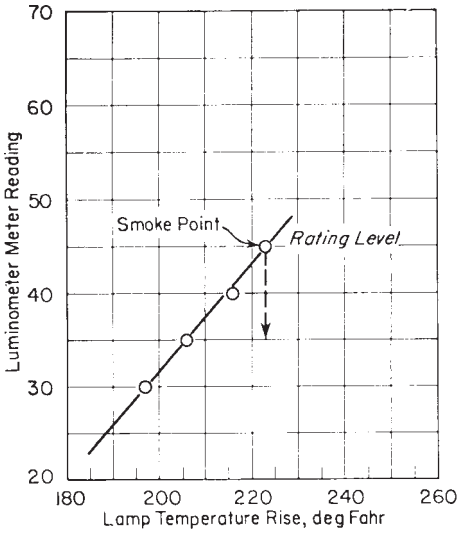
9.4 Run two samples of ASTM reference fuel grade *iso* octane as described in 9.1-9.3, but obtain four data points, two below and two above the rating level established with tetralin for the instrument. (The four data points should be uniformly separated by approximately 10 luminosity units.) One of the samples should be run before running the unknown test fuel; the other sample should be run after running the test fuel. Plot two curves, and at the rating level, find the lamp temperature rise for each sample of *iso* octane (Fig. 3). Average these values.

9.5 Run one sample of the unknown test fuel in the manner described for *iso* octane and determine the lamp temperature rise for this fuel (Fig. 4). Use this value and the average ΔT's of tetralin and *iso*octane to calculate the luminometer number of this test fuel.

NOTE 9—If a number of unknown test fuels are to be tested, the second sample of *iso*octane may be run after all of the unknown test fuels, provided all of these runs are made the same day.

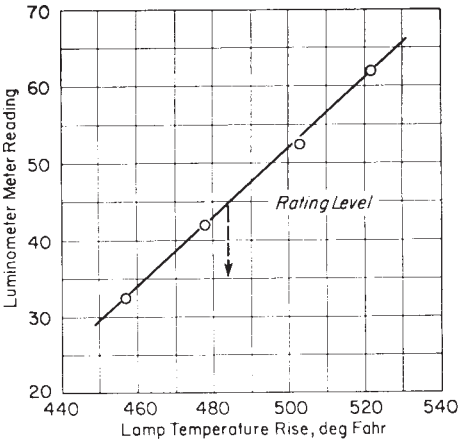
NOTE 10—Fuels that have high luminometer numbers are prone to form condensation and are greatly affected by air leaks or leveling errors. Preheating the interior of the cabinet with a small drop light, or using a slow step-type warmup will prevent condensation problems. If condensation is encountered, meter readings will become unstable and moisture will appear on the peep-hole glass. If condensation is encountered, it can be removed by allowing the fuel to burn with the lamp door removed until all moisture clears from the filter glass and holder.

NOTE 11—Fuels that have very low luminometer numbers frequently smoke at relative low meter readings. The absence of a smoking flame with fuels giving a low-temperature rise should be assured by observation



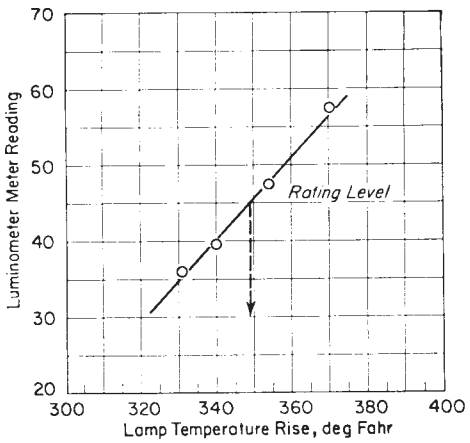
Fuel	Tetralin
Luminometer No.	02L-1
Barometer, in. Hg	29.92
Wet bulb temperature	59°F (15°C)
Dry bulb temperature	77°F (25°C)
Background to be measured with sample holder in lamp, no flame, door closed, and Luminometer meter zeroed	0
Lamp temperature rise at rating level	233°F

FIG. 2 Rating Level of Tetralin



Fuel	*Iso*octane
Barometer, in. Hg	29.92
Wet bulb temperature	59°F (15°C)
Dry bulb temperature	77°F (25°C)
Background to be measured with sample holder in lamp, no flame, door closed, and Luminometer meter zeroed	0
Lamp temperature rise at rating level	484°F

FIG. 3 Lamp Temperature Rise at Rating Level of *Iso*octane



Fuel	Test Fuel
Luminometer No.	02L-1
Barometer, in. Hg	29.92
Wet bulb temperature	59°F (15°C)
Dry bulb temperature	77°F (25°C)
Background to be measured with sample holder in lamp, no flame, door closed, and Luminometer meter zeroed	0
Lamp temperature rise at rating level	349°F

FIG. 4 Lamp Temperature Rise at Rating Level of the Test Fuel

through the peep hole in the lamp door. Clean the optical filter and thermocouple shield if a smoky flame has been encountered.

10. Calculation

10.1 Calculate the luminometer number of the test fuel as follows:

$$\text{Luminometer number} = \frac{\Delta T \text{ test fuel} - \Delta T \text{ tetralin}}{\Delta T \textit{ iso}\text{octane} - \Delta T \text{ tetralin}} \times 100 \qquad (1)$$

where the ΔT's for the tetralin and *iso*octane are the average values obtained at the rating level of tetralin.

11. Precision and Bias [9]

11.1 The precision of this test method as determined by the statistical examination of interlaboratory test results is as follows.

11.1.1 *Repeatability*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions would, in the long run, in the normal and correct operation of the test method exceed the following value only in one case in twenty.

$$\text{Repeatability} = 6.1 \text{ luminometer numbers} \qquad (2)$$

11.1.2 *Reproducibility*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the long run, exceed the following value only in one case in twenty.

$$\text{Reproducibility} = 8.8 \text{ luminometer numbers} \qquad (3)$$

NOTE 12—The preceding precision was obtained in a program using the Luminometer made by ERDCO Engineering Corporation. Equipment not equivalent to this apparatus can give results of different precision.

11.2 The precision of test method is not known to have been obtained in accordance with currently accepted guidelines (for example, in Committee D-2 Research Report RR:D02-1007, "Manual of Determining Precision Data for ASTM Methods and Petroleum Products and Lubricants."[10]

NOTE 13—Seven laboratories tested nine fuels varying in volatility and luminometer rating. Seven were aviation fuels including fuels meeting Specification D 1655, and two were gas turbine fuels (No. 1 and No. 2) as designated in Specification D 2880, for Gas Turbine Fuel Oils. One laboratory was excluded from analysis for failure to complete testing. There was no significant variation in precision with luminometer rating level.

11.3 *Bias*—The procedure in Test Method D 1740 has no bias because the value of luminometer numbers can only be determined in terms of the test method.

12. Keywords

12.1 aviation fuel; flame radiation; gas turbine distillate fuels; luminometer number

[9] Supporting data may be obtained from ASTM Headquarters. Request. RR:D02-1180.

[10] *Annual Book of ASTM Standards*, Vol 05.03.

ANNEX

(Mandatory Information)

A1. WARNING STATEMENTS

A1.1 *Iso*octane

Warning—Extremely flammable. Harmful if inhaled. Vapors may cause flash fire.

Keep away from heat, sparks, and open flame.

Keep container closed.

Use with adequate ventilation.

Avoid build-up of vapors and eliminate all sources of ignition, especially nonexplosionproof electrical apparatus and heaters.

Avoid prolonged breathing of vapor or spray mist.

Avoid prolonged or repeated skin contact.

A1.2 Tetralin

Warning—Combustible. Vapor harmful. In animal tests, repeated oral or inhalation exposures caused liver and kidney damage and the formation of eye cataracts.

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing vapor or spray mist.
Avoid prolonged or repeated contact with skin.

A1.3 Acetone

Warning—Extremely flammable. Vapors may cause flash fire.

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid build-up of vapors, and eliminate all sources of ignition, especially nonexplosionproof electrical apparatus and heaters.
Avoid prolonged breathing of vapor or spray mist.
Avoid contact with eyes or skin.

A1.4 Toluene

Warning—Flammable. Vapor harmful.

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing of vapor or spray mist.
Avoid prolonged or repeated contact with skin.

A1.5 Methanol (methyl alcohol)

Warning—Flammable. Vapor harmful. May be fatal or cause blindness if swallowed or inhaled. Cannot be made nonpoisonous.

Keep away from heat, sparks, and open flame.
Keep container closed.
Avoid contact with eyes and skin.
Avoid breathing of vapor or spray mist.
Use with adequate ventilation.
Do not take internally.

APPENDIX

(Nonmandatory Information)

X1. SMOKE POINT-LUMINOMETER NUMBER RELATIONSHIP

X1.1 Introduction

X1.1.1 There is a good correspondence between smoke point (SP) (Test Method D 1322) and luminometer number (LN) (Test Method D 1740). Fig. X1.1 shows this relationship for aviation turbine fuels of the kerosine type.

X1.1.2 The relationship is based on regression of data on 315 fuels having luminometer numbers falling within the range from −2 to 100. There were 160 Jet A, A-1, JP-4, and JP-5 fuels in this group. The remaining fuels were diesel fuels, kerosines, blends of refinery fractions, and other miscellaneous petroleum fractions.

X1.1.3 The correlation coefficient was 0.95.

X1.1.4 It can be demonstrated that the confidence intervals about the correlation line is explainable almost completely by the inherent error in the smoke point and luminometer measurements. This means that if there is a fuel-type effect different for each of the two methods, it is small and masked by smoke point and luminometer number measurement errors.

X1.2 Equations

X1.2.1 The correlation curve shown in Fig. X1.1 can be represented by either equation as follows:

$$LN = -12.03 + 3.009SP - 0.0104SP^2 \quad \text{(X1.1)}$$

$$SP = +4.16 + 0.331LN + 0.000648LN^2$$

X1.2.2 The equations are obviously not mathematical identities but yield results that do not differ by more than 0.1 smoke point or luminometer number points. Both equations are presented to facilitate ease of calculation depending on which variable is given.

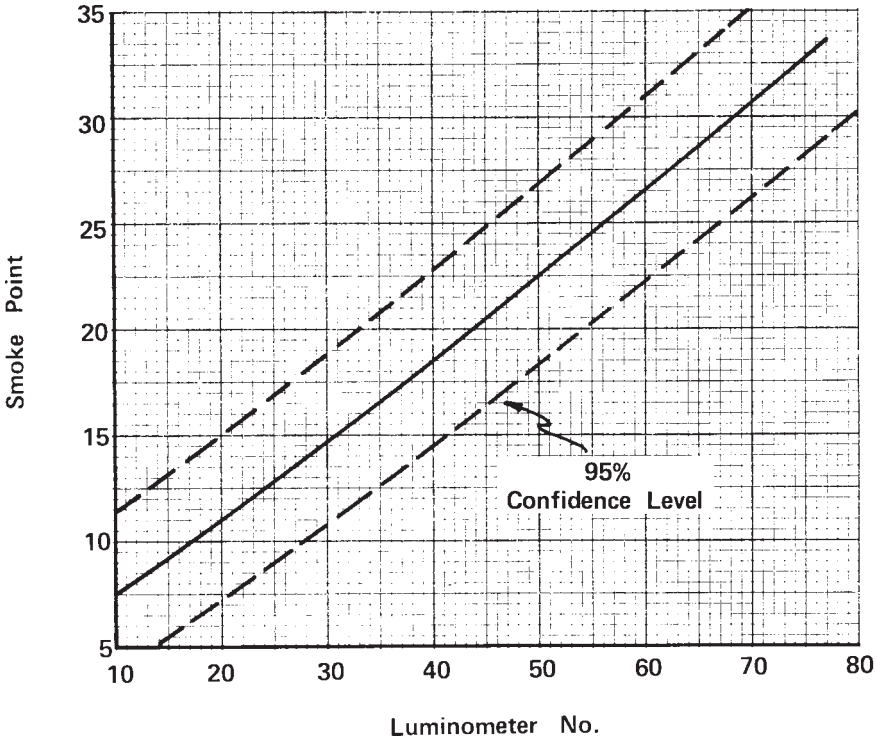


FIG. X1.1 Relationship Between Smoke Point and Luminometer Number